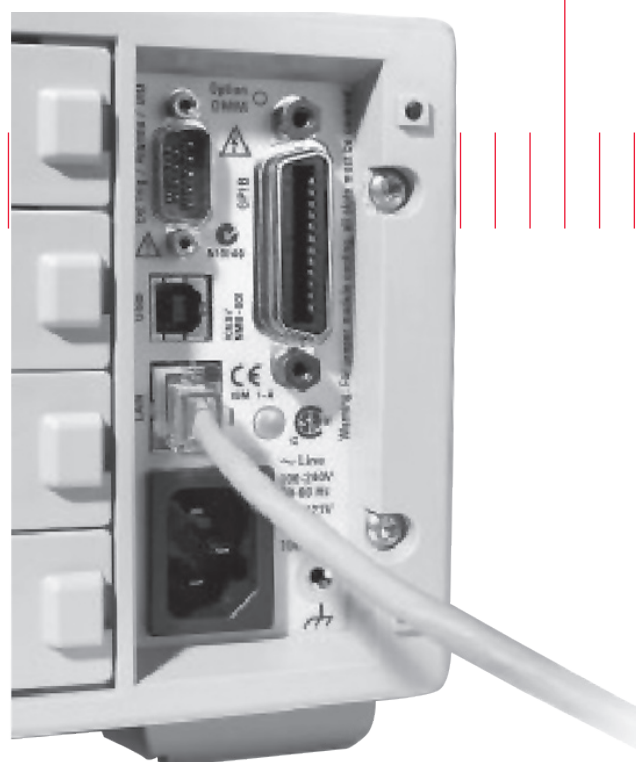


# Keysight Technologies

## Tips and Tricks for Using USB, LAN, and GPIB

Application Note



## Introduction

GPIB has been and will continue to be a popular choice for input/output (I/O) in test equipment. However, with high performance LAN and USB ports built into most current generation PCs, many test-system developers are ready to explore the benefits of using LAN or USB for instrument I/O.

Keysight Technologies, Inc. was one of the first test-and-measurement (T&M) manufacturers to enable those benefits by including LAN and USB ports in its instruments and by offering I/O drivers, software, and configuration tools that make connections as easy as using GPIB. Along the way, Keysight has been working with other manufacturers to develop T&M-specific standards that enhance LAN and USB for use in test systems.

This application note provides a variety of tips and tricks that will help you create flexible test systems that can easily incorporate USB, LAN, GPIB, and RS-232C. By expanding your range of I/O alternatives you can enable new usage models that boost productivity, and add new tools that protect your investments in system hardware and software. The foundation of these benefits is an approach we call Keysight Open, which simplifies system development through system-ready instrumentation, open software environments, and PC-standard I/O.

## Tip:

Utilize faster, simpler I/O that's built in

Most current-generation PCs include one high-speed LAN port and multiple USB ports. An increasing number of measurement instruments—and most new Keysight instruments—now include LAN and USB ports alongside the GPIB connector. It's likely that all three interfaces will coexist for years to come.

Compared to GPIB, the PC-standard interfaces offer similar or superior performance with greater convenience and lower cost.<sup>1</sup> Because the interfaces are built into today's PCs, there is no need to open the computer and install a GPIB card. What's more, high quality LAN and USB cables are typically less expensive than a GPIB cable of equal length. With these advantages, LAN and USB will often be a better choice than GPIB (or extensions such as HS-488) when creating a new test system.

If you're concerned about instrument programming, two recently developed T&M standards ensure that it's virtually identical whether you use GPIB, LAN or USB. The VXI-11 protocol defines LAN-based communication for all types of test equipment, not just VXI, and the USBTMC-USB488 standard extends USB for T&M applications.

VXI-11 and USBTMC both create an I/O connection that looks just like GPIB to a PC-based application. This means existing GPIB programs—and everything you've learned over the years about GPIB programming—can be used virtually unchanged if you choose to connect via LAN or USB. This is especially true if you also use the VISA I/O API.<sup>2</sup> With USB, the only additional step is setting the instrument address to meet the USB naming convention.

Keysight initiated the creation of both VXI-11 and USBTMC and is committed to driving the T&M industry toward wider use of PC-standard I/O. We will also continue to work with other instrument vendors to define and develop open standards that will deliver technical and economic advantages to system developers.

1. To ensure top performance, isolate the LAN or USB connection from any non-instrumentation data traffic.
2. Virtual Instrument Software Architecture input/output application programming interface. To learn more, please see the glossary on page 11.

## Trick:

### Connect to GPIB instruments via USB (or LAN)

Envision a brand new desktop or notebook PC sitting on your desk. Now imagine that you'd like to connect it to the oscilloscope on your workbench and then step through some saved configurations, make a few quick measurements, transfer the data, and analyze the results. There's one small problem: the PC has LAN and USB interfaces but the scope has a GPIB port. Fortunately, a handy converter unit makes it easy to connect GPIB instruments to your new PC.

The Keysight 82357B USB/GPIB interface allows you to connect instruments directly via one of the PC's USB ports—no switches to set, no PC cards to install. In fact, with the typical GPIB daisy-chain approach you can connect up to 14 instruments to a single USB port through an 82357B. This type of configuration is great for benchtop applications because USB is so simple to set up and use.

LAN works, too: The Keysight E5810A LAN/GPIB gateway enables easy, direct communication via the PC's LAN port. As with the USB/GPIB interface, you can use the E5810A to connect up to 14 daisy-chained GPIB instruments to the PC. The gateway also includes a single RS-232C port that can be used for serial communication with the DUT, a test fixture or other device. This type of arrangement is well suited to design verification and manufacturing applications that require high performance systems.

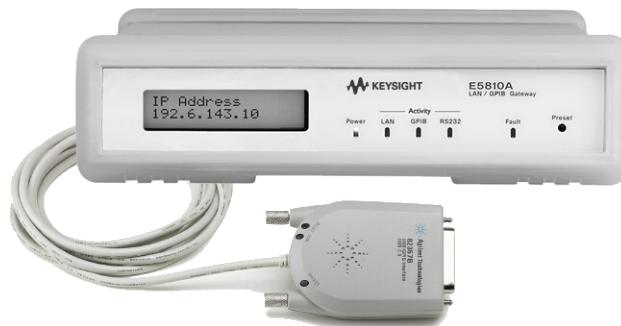


Figure 1. The Keysight 82357B USB/GPIB interface and E5810 LAN/GPIB gateway enables easy connection between PCs and GPIB instruments

## Trick:

### Create a “hot pluggable” system with USB

USB is all about ease of use: it provides plug-and-play connections that allow “hot” removal of devices from a PC or of the PC from a test system. This means you no longer need to set aside a dedicated computer for instrument control. Instead, you can simply connect any instruments and peripherals to a self-powered USB 2.0 hub just be sure to get one with enough ports to accommodate all of the equipment you want to use.<sup>3</sup>

A single USB cable is all it takes to link a PC to every device plugged into the hub. This makes it easy for anyone to connect their PC to the system, and makes it easy to keep the system intact on a bench or cart. For larger systems, you can use multiple hubs with no drop in performance. When you connect the hub to a computer, Microsoft Windows will automatically discover and connect all of the USB devices. If the PC is running the Keysight IO Libraries Suite, you can get the system up and running very quickly by launching Keysight Connection Expert, which can discover instruments connected via USB and GPIB. Keysight Connection Expert can also find LAN-connected instruments: it can directly find instruments on the same subnet, and can also find a remote instrument if you enter its IP address.

To handle up to 14 GPIB instruments, you can connect an 82357B USB/GPIB converter to the hub. You can also add up to four RS-232C devices with a single Keysight E5805A USB/4-Port RS232 interface. These ports can be used as COM ports or programmed directly via the Keysight IO Libraries Suite.

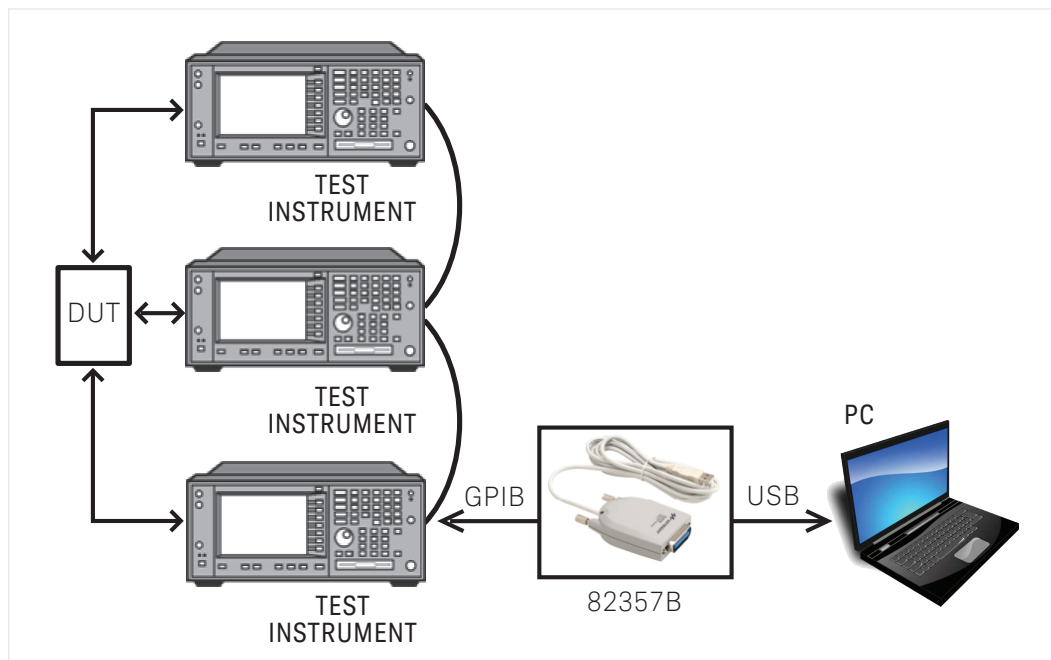


Figure 2. A self-powered USB hub makes it easy to create a hot-pluggable system that anyone can connect to and use

*3. To ensure top performance and reliable, consistent operation, use a USB 2.0 hub that has an external AC adapter; we also recommend using a USB 2.0 hub and USB 2.0-compatible cables, even if the attached devices are USB 1.1.*

## Tip:

### Keep things simple with a private, independent network

In some organizations, the adoption of LAN-based instruments and systems is being slowed by the need for IT involvement, which is often driven by concerns about network security and performance. You may be able to avoid these issues by creating a private network that is reserved for use by a standalone test system.

If you choose to use a dedicated PC, the LAN-based system can be completely isolated from the company intranet and the Internet. This has two important advantages. First, it preserves system performance by shielding it from the volume of data traffic carried on the intranet (conversely, it also shields the intranet from potentially heavy system communication). Second, this approach also isolates the system from any malicious threats that might reach the intranet from the Internet.

If you want or need access to the intranet and beyond, you can create a security buffer by adding a second LAN card to the PC and activating the Internet Connection Sharing (ICS) feature in Windows XP. In this configuration the host PC serves as the router for the private network, using ICS to (1) route traffic from one LAN card to the other and (2) provide Network Address Translation (NAT) services for the private IP addresses in the network. Keysight Application Note 1465-10, Using LAN in Test Systems: Network Configuration provides detailed descriptions of this approach and a router-based method.

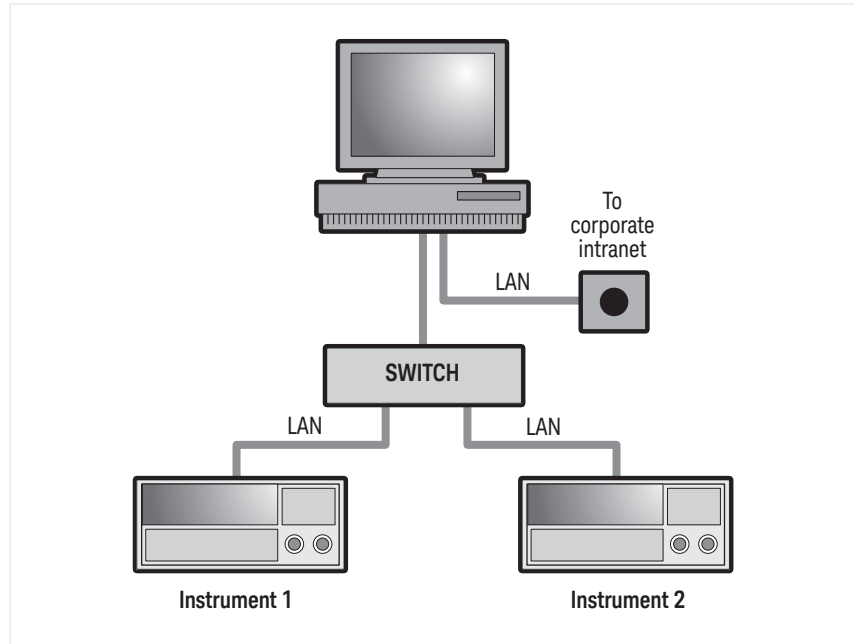


Figure 3. A PC configured with two LAN cards enables the creation of a private, protected network that can also access the corporate intranet

## Trick:

### Standardize to simplify connections and programming

If you have several people who run similar tests, consider defining and building a standard test system or test bench. The system-to-PC connection will need just one cable if you standardize on a USB hub, LAN switch or similar device. For automated, repetitive testing you might want to also connect essential peripherals – printers, barcode readers, custom operator interfaces – through an appropriate hub. Three examples will illustrate some of the possibilities.

- Development lab: First, identify a standard set of basic and common instruments. Then, if the system is connected via USB or as a private LAN, you can apply standardized addressing to every device. You can also easily attach a USB printer or configure a standard network printer.
- Test station: Start with a standard set of basic and common instruments then add a barcode reader for easy entry of DUT information. To control operator access, consider adding a biometric security device to the system. If you need RS-232C ports to connect the barcode reader or control the DUT or a test fixture, use the E5805A to add a four-port serial interface to the system.<sup>4</sup>
- Portable calibration system: Put the standardized system instruments, printer, and barcode reader on a wheeled cart for easy transport within or between facilities. You could even add a hefty uninterruptible power supply (UPS) to the bottom of the cart. This would help prevent inadvertent shutdowns during a calibration and also allow battery operation while moving the system, reducing warm-up time at your next stop.

To simplify programming, you could also adopt a standard addressing protocol for all system devices. The Keysight IO Libraries Suite makes this “GPIB simple” by letting you assign descriptive, user-friendly names (aliases) to each instrument or resource. As an example, you can assign a function generator any name you like even though it resides at a specific IP address.

4. If the E5810A LAN/GPIB gateway is part of your configuration, it includes a single RS-232C port for connecting serial devices.

## Trick:

### Enable instrument sharing via LAN

A LAN connection makes it possible for multiple users to access instruments via the company intranet or the Internet – but be sure to employ all relevant and required security measures. Shared access is especially helpful if several people need to use equipment that must be borrowed from a loaner pool but could instead be kept in a common work area. LAN-based sharing is also very useful if a geographically dispersed team is working on a one-of-a-kind prototype that is co-located with its test system. Of course, you can also access the system locally via the LAN interface of any PC you bring to the system.

If the PC and instruments all support the VXI-11 protocol, it will enable session locking and prevent other users from accessing the system during a test. If VXI-11 isn't available, some form of manual scheduling may be required to prevent conflicts. As an example, if your organization uses Microsoft Outlook you could create a mailbox and calendar for an instrument (or system) and let the team use Outlook to schedule their tests.

#### LAN provides the longest reach

Compared to GPIB and USB, LAN enables instrument sharing, remote operation and test monitoring over much greater distances. In the simplest configuration, a single LAN segment can be as long as 100 meters (328 feet). The addition of a hub stretches that distance up to 1,600 meters (about one mile). A LAN's reach becomes virtually unlimited – though typically with lower performance – when you add routers, switches, bridges, or **repeaters**.

## Trick:

### Operate instruments and monitor tests from a remote PC

Today, many LAN-enabled instruments are equipped with built-in Web servers. Through the instrument's LAN port, you can use a local or remote PC to access internal Web pages that let you configure, calibrate and operate the unit. As an example, you could log in from home and instruct an instrument to calibrate itself – and it will be ready to use by the time you arrived at work.

If the system includes a mix of LAN and GPIB-based instruments, the E5810A LAN/GPIB gateway provides similar capabilities. Its Web interface allows you to communicate with any connected GPIB instrument or RS-232C device. When using instruments such as DMMs and oscilloscopes, the Web server may also enable remote monitoring of measurements and provide access to measured data. For example, some built-in Web servers can display measured values or waveforms so you can check the progress of a test or the state of the DUT.

Some LAN-enabled instruments provide even greater functionality. Inside every Keysight Infiniium product is a PC running custom software and a version of the Windows operating system. Windows has several LAN services built in, enabling capabilities such as the sharing of files, folders, drives, and printers.

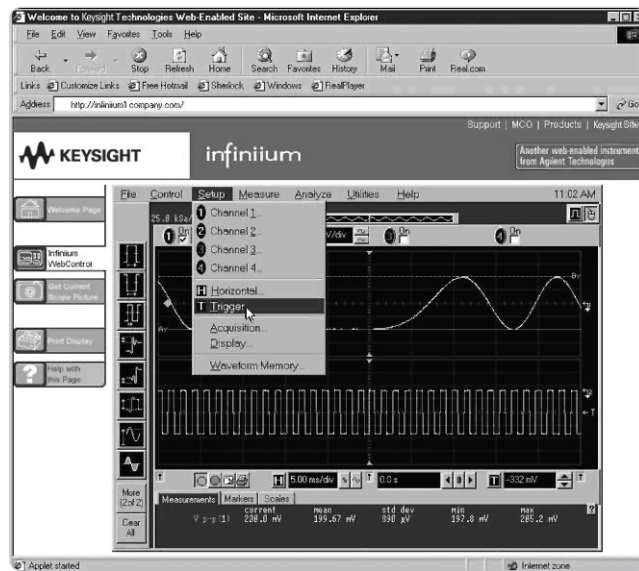


Figure 4. The virtual front panel of a Keysight Infiniium oscilloscope enables browser-based operation of the instrument



## Tip:

### Overcome cabling issues by using wireless connections

A variety of situations make it difficult to reach a test system with an interface cable. Perhaps the distance exceeds the maximum length of a GPIB or USB connection. Maybe the system is in a hazardous or inconvenient location. You're in a hurry and can't wait for facilities staff to pull new cabling. Or maybe you're simply on the wrong side of the hallway and can't safely string a cable to the test system.

Whatever the reason, try going wireless. You may need permission from your local IT staff but it's relatively easy to set up a small, secure wireless network using basic capabilities such as address filtering and shared security keys. Creating a secure, dependable wireless LAN (WLAN) may take a bit more time than configuring a wired network, but once the WLAN is set up, connecting and disconnecting couldn't be easier.

To help you get started, the Keysight Application Note 1465-9 covers the basics of using LAN in test systems and also provides a few notes about WLAN technologies. The Keysight Application Note 1465-14 provides greater detail, covering application issues such as WLAN set up, configuration and advanced security techniques. If you'd like to learn more about the successful use of WLAN, LAN, and USB in test systems, please refer to the complete list of 1465-series application notes on page 11.

### Shaping the future of test system development

Today, Keysight is leading the way in the creation of flexible test systems based on system-ready instrumentation, open software environments, and PC-standard I/O. As an example, we're continually introducing new additions to what is currently the industry's largest portfolio of LAN-enabled instruments. At the same time, we're also protecting your investment in GPIB-only instruments by offering devices such as the E5810A LAN/GPIB gateway, the 82357B USB/GPIB interface, and the 82350A GPIB/PCI card.

To discover more ways to accelerate system development, simplify system integration and apply the advantages of open connectivity, please visit the Keysight Open Web site at [www.keysight.com/find/open](http://www.keysight.com/find/open).

Once you're there, you can also sign up for early delivery of future application notes in this series. Just look for the link "Join your peers in simplifying test-system integration."

## Related literature

The latest additions to the 1465 series of application notes provide a wealth of information about the successful use of LAN, WLAN, and USB in test systems:

- *Using LAN in Test Systems: The Basics*, AN 1465-9 (pub no. 5989-1412EN) <http://literature.cdn.keysight.com/litweb/pdf/5989-1412EN.pdf>
  - *Using LAN in Test Systems: Network Configuration*, AN 1465-10 (pub no. 5989-1413EN) <http://literature.cdn.keysight.com/litweb/pdf/5989-1413EN.pdf>
  - *Using LAN in Test Systems: PC Configuration*, AN 1465-11 (pub no. 5989-1415EN) <http://literature.cdn.keysight.com/litweb/pdf/5989-1415EN.pdf>
  - *Using USB in the Test and Measurement Environment*, AN 1465-12 (pub no. 5989-1417EN) <http://literature.cdn.keysight.com/litweb/pdf/5989-1417EN.pdf>
  - *Using SCPI and Direct I/O vs. Drivers*, AN 1465-13 (pub no. 5989-1414EN) <http://literature.cdn.keysight.com/litweb/pdf/5989-1414EN.pdf>
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  - *Using LAN in Test Systems: Setting Up System I/O*, AN 1465-15 (pub no. 5989-2409) <http://literature.cdn.keysight.com/litweb/pdf/5989-2409EN.pdf>
- Earlier notes in the 1465 series provide additional hints that can help you develop effective test systems:
- *Introduction to Test System Design*, AN 1465-1 (pub no. 5988-9747EN) <http://literature.cdn.keysight.com/litweb/pdf/5988-9747EN.pdf>
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  - *Operational Maintenance*, AN 1465-8 (pub no. 5988-9823EN) <http://literature.cdn.keysight.com/litweb/pdf/5988-9823EN.pdf>

## Glossary

**API** – application programming interface; a well-defined set of software routines through which an application program can access the functions and services provided by an underlying operating system or a reusable software library

**Bridge** – a LAN device that connects segments of a network

**DHCP** – dynamic host configuration protocol; a method of automatically obtaining an IP address for a LAN-connected device (e.g., PC, router or instrument)

**DDNS** – dynamic domain name server; a service that allows a network device to establish its host name when it connects to the network; lets other devices use that host name with DNS to find the device's IP address and connect to it

**DNS** – domain name server; maps specific names to IP addresses, enabling use of names in place of IP addresses in test programs

**Driver** – also called an instrument driver; a collection of functions resident on a computer and used to control an instrument (e.g., DMM, oscilloscope or network analyzer); an alternative to SICL and VISA

**DUT** – device under test; the component, subassembly, or product to be measured by the test system

**Ethernet** – a specific LAN technology that is the dominant implementation of the physical and data link layers; also known as IEEE 802.3

**Firewall** – a hardware device or software program (or combination) that protects a computer network from unauthorized access

**Gateway** – a hardware device that connects devices that use different standards and protocols (e.g., LAN to GPIB)

**GPIB** – General Purpose Interface Bus; the dominant 8-bit parallel I/O connection for test equipment and test systems

**HP-IB** – Hewlett-Packard Interface Bus; another name for GPIB

**Hub** – a multi-port LAN device that connects multiple devices together, usually in a star topology; a multipoint USB device that connects multiple devices to a single USB port

**IEEE 488** – Institute of Electrical and Electronics Engineers standard for HP-IB; another name for GPIB

**IP** – Internet protocol; requires an address to communicate

**IVI** – Interchangeable Virtual Instruments; a standard instrument driver model that allows a consistent programming style across instrument models and classes

**IVI-COM drivers** – also called IVI component drivers; presents the IVI driver as a COM object, preserving the full capabilities of COM-enabled development environments

**LAN** – local area network

**Library** – a collection of callable software operations; reusable software functions meant to be used by other programs

**NAT** – Network Address Translation; maps private addresses to one or more public addresses to enable access to intranet or Internet

**Repeater** – a LAN device that extends the length of a network segment by reading, regenerating, and repeating all incoming signals

**Router** – a LAN device that joins multiple networks and enables creation of small, private networks

**SICL** – Standard Instrument Control Library; a modular instrument communications library that works with a variety of computer architectures, I/O interfaces and operating systems; largely superseded by VISA

**SNMP** – Simple Network Management Protocol; a standard TCP/IP protocol that enables monitoring and mapping of network availability, performance, and error rates

**Subnet** – a group of connected network devices; used to partition networks into segments for easier administration

**Subnet mask** – a setting that accompanies an IP address and defines the boundaries of a subnet

**Switch** – a LAN device that connects multiple devices to a single LAN line; however, unlike a hub, it preserves full network bandwidth to each device

**TCP/IP** – Transfer Control Protocol and Internet Protocol; the two standards that provide the data communication foundation of the Internet

**UPnP** – Universal Plug and Play; a networking architecture that ensures compatibility between devices, software, and peripherals; not the same as Plug and Play or VXIplug&play drivers

**USB** – Universal Serial Bus; designed to replace the RS-232 and RS-422 serial buses used in PCs

**VISA** – Virtual Instrument Software Architecture; sometimes called VISAC; a common foundation for system software components, including instrument drivers, virtual front panels, and application software; consists of a vendor-independent set of instrument communication operations that work across different I/O interface technologies

**VISA COM** – provides the services of VISA in a COM-based API; a subset of VISA in terms of I/O capabilities but includes some services not available in VISA

**VXI** – VME extensions for instrumentation; a standard, open architecture for modular test instrumentation and systems

**VXIplug&play** – a popular driver technology for all types of instrumentation; provides a consistent programming style across instruments; some VXIplug&play drivers include virtual front panel technology that allows development environments to provide extra help and visual guidance for operating an instrument

**Wi-Fi** – Wireless Fidelity; the marketing name for the various IEEE 802.11 wireless LAN standards

**WLAN** – wireless LAN; a flexible way to communicate with hard-to-reach test systems

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